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14. ABSTRACT The increasing contact of the U.S. military with wicked problems over the last 20 years has driven the development of Design as a non-linear problem solving methodology. Doctrine provides little guidance on how Design is conducted. Commanders used to traditional military planning process experience difficulty in leading and implementing a problem solving methodology lacking structure. This discussion presents General Morphological Analysis as a suitable Design mechanism to add structure to solving wicked problems. A general background on wicked problems, problem solving theory, and GMA is presented to the reader to facilitate an understanding of the discussion. It identifies military problems as wicked problems and explains how GMA embodies Design's process and meets Design's goals through application of Design's fundamentals. The Columbian-FARC problem-complex is modeled to demonstrate how GMA functions as a suitable Design mechanism. Finally, this discussion logically links GMA to Design and recommends that GMA becomes a mechanism for Design.					
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DESIGN'S MECHANISM – GENERAL MORPHOLOGICAL ANALYSIS

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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04 May 2012

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Definition of Key Terms

1. Design: A methodology for applying critical and creative thinking to understand, visualize, and describe complex, ill-structured problems and develop approaches to solve them.ⁱ
2. Empirical Constraints: A practical incompatibility or discrepancy between two or more factors about the observed world.ⁱⁱ
3. Factors: (also known as Conditions) A parameter's component parts; different values a parameter can take on the parameter's range.ⁱⁱⁱ
4. General Morphological Analysis: A method for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable, problem complexes.^{iv}
5. Logical Contradictions: A logical incompatibility or contradiction between two or more factors about the observed world.^v
6. Morphological Field: The field constructed factors or parameters assessed and linked through a Cross Consistency Analysis.^{vi}
7. Multiplex Modeling: A General Morphological Analysis method joining multiple morphological fields together that represents various frames-of-reference of the problem complex.^{vii}
8. Normative Constraints: An incompatibility or discrepancy between two or more factors based on social norms, ethics, and standards.^{viii}
9. Parameters: One of a set of measurable components that defines the system and determines its behavior, and which can be varied in an experiment.^{ix}
10. Planner(s): All stakeholders attempting to solve or influence a problem complex; in this discussion planner(s) is used to represent the commander and staff.
11. Problem Complex: The totality of all conceivable parameters and factors that affect the problem; to include the problem and problem solution.^x
12. Solution Space: The subset of all configurations in a morphological model which fulfill the requirement of being internally consistent, and thus being a possible solution.^{xi}
13. Wicked Problem: Complex, ill-structured, and adaptive problem.^{xii}

Abstract

The increasing contact of the U.S. military with wicked problems over the last 20 years has driven the development of design as a non-linear problem solving methodology. Doctrine provides little guidance on how design is conducted. Commanders used to traditional military planning process experience difficulty in leading and implementing a problem solving methodology lacking structure. This discussion presents General Morphological Analysis as a suitable design mechanism to add structure to solving wicked problems. A general background on wicked problems, problem solving theory, and GMA is presented to the reader to facilitate an understanding of the discussion. It identifies military problems as wicked problems and explains how GMA embodies design's process and meets design's goals through application of design's fundamentals. The Colombian-FARC problem-complex is modeled to demonstrate how GMA functions as a suitable design mechanism. Finally, this discussion logically links GMA to design and recommends that GMA becomes a mechanism for design.

INTRODUCTION

*I need you to be clever, Bean. I need you to think of solutions to problems we haven't seen yet. I want you to try things that no one has ever tried because they're absolutely stupid.*¹³

- Ender Wiggin, *Ender's Game*

The natural environmental states that the U.S. military exists in are ill-defined, adaptive, problem-complexes. World War II, Korea, and the Cold War applied controlled conditions on the natural “problem-complexes”¹⁴ creating artificial structure on these problem-complexes. Over time the U.S. military accepted the normal artificiality. U.S. military leaders adopted Operational Research (OR) planning techniques which deconstructed the enemy and operating environment into manageable elements.¹⁵ Globalization and the end of the Cold War removed the controlled conditions on problem-complexes and reintroduced the natural environmental state to an unprepared U.S. military. Military leaders struggled with applying traditional military problem solving techniques to unconstrained problem-complexes. As a result of this intellectual struggle, design was developed. Design, as described in FM 5-0, is a non-linear problem solving methodology applied to complex, ill-structured problems that leverages the creative and critical thinking of the Operational Commander and staff.¹⁶

General Morphological Analysis (GMA) provides the Operational Commander and staff with a mechanism to conduct design when presented with a wicked problem-complex. As a methodology, design is attractive because it focuses effort on the problem-complex and not the problem solving process. This is important because planners are normally tied to a rigid planning process, but design allows planners to explore the problem-complex and understand it without being bound by process. However, FM 5-0 provides little to no guidance on how to conduct design. A thorough exploration of the acceptability and suitability of GMA as a design mechanism is required. The validity of design, either for or

against, will not be explored. This exploration will include: theory that develops a base line understanding of wicked problems and problem-complexes, non-linear problem solving, and GMA; mechanistic discussion of GMA as it pertains to design and military wicked problems; and GMA case study as it applies to the Colombian-Revolutionary Armed Forces of Colombia (FARC) problem-complex.

COUNTER-ARGUMENT

Prior to exploring the acceptability and suitability of GMA as a design mechanism, it is important to understand the primary opposing views to fully appreciate the utility of GMA. Once introduced into the U.S. military community, there will be three major opposing views of GMA. First, the majority of the opposition will argue that GMA is just another form of General Systems Theory (GST) similar in nature to the dismissed Effects Based Operations (EBO) and Systemic Operational Design (SOD) problem solving methods and is not acceptable for use within military planning processes. Conversely, the second opposition group will accept GMA as distinct from EBO or SOD, but will argue that GMA is not a suitable design mechanism. The third argument flows along the objection that design is not an acceptable military problem solving method. Only the first two objections will be addressed. The third point of view, although a valid objection, will not be addressed as it falls outside the scope of this discussion.

EBO or SOD in Sheep's Clothing

Militaries throughout the 1990's and the 2000's adopted various GST methods into planning doctrine to rationally solve wicked problem-complexes.¹⁷ The U.S. and Israeli militaries adopted EBO and SOD theoretical methods to address shortfalls in their hierarchical planning processes. Unfortunately for both the U.S. and Israel, EBO and SOD

failed to perform to desired expectations.¹⁸ This is reminiscent of Clausewitz's contemporaries attempting to wage war through Newtonian or scientific methods. Clausewitz asserted that the complexity, uncertainty, and intangibles of war prevent commanders and planners from applying scientific methods to war.¹⁹ GST, attempting to use only scientific methods to impose structure on wicked problems-complexes, will lead to a misunderstanding of the problem, and ultimately to a mismatch between ends, ways, and means. General Mattis identified these shortfalls and issued guidance in 2008 to remove EBO, associated terms, and concepts from joint doctrine.²⁰

GST opponents will incorrectly associate GMA as another attempt by systems theorists to solve wicked problems by applying rationality to uncertainty in an attempt to determine causal relationships between variables in the wicked problem-complex. Although GMA does apply some rationality to uncertainty, it definitely does not determine causal relationships between variables. GMA generates a “non-quantitative model”²¹ that allows the user to view all possible frames-of-reference or “solution spaces”²² of the wicked problem. Human cognition and judgment is still required to generate variables, evaluate variable relationships, and creatively apply the solution space to the wicked problem-complex.

GMA is not Design Compatible

The second valid objection is that GMA is not a suitable mechanism for design. The baseline argument is that GMA imposes structure on a method that is purposely structurally amorphous; therefore, it defies the purpose behind the design concept. Design is essentially composed of the three elements of design: framing the operational environment, framing the problem, and consider operational approaches.²³ Design's elements must not be construed as

steps that are performed in a logical order, but as activities that occur opportunistically in sequence, simultaneously, or cyclically depending on states of uncertainty present in the problem-complex. GMA embodies the three design elements and achieves design's four goals by applying design's five fundamentals.²⁴

WICKED PROBLEM & WICKED PROBLEM SOLVING THEORY

Without a basic understanding of wicked problem and problem solving theory, this discussion will only provide a good brief on GMA. The reader will not really appreciate the potential that GMA offers as a mechanism for design. This section will provide an in-depth presentation of wicked problems and introduce the concept of wicked problem-complexes, a general survey of non-linear problem solving, and a brief history of GMA.

Wicked Problem and Wicked Problem Complex

What is a wicked problem, and what is a wicked problem-complex? Up to this point in the discussion wicked problems were portrayed as complex, ill-structured, and adaptive, but they are more involved than these three characteristics. In 1973 Rittel and Webber stratified problems into either "tame" or "wicked", and characterized wicked problems with the following ten distinguishing properties.

1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not true-or-false, but good-or bad.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a "one-shot" operation; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
6. Wicked problems do not have enumerable set of potential solutions, nor is there a well described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution.
10. The planner has no right to be wrong.²⁵

The human dimension of a problem-complex drives these ten properties in creating the wicked problem. Since war is a human endeavor, most military problems encountered at the operational level are wicked problems and hence, involve these ten properties. The planner, understanding the role of these ten properties in making military situations into wicked problems, employs effective ways and means to solve the problem. In principle, these ten properties are straightforward in their meaning, but further investigation of properties one, three, five, and ten reveal their complex affect on military planning. Although only the effects of four properties are discussed below, all ten properties are important to remember when solving a wicked problem.

“There is no definitive formulation of a wicked problem,” is probably the hardest property to overcome. A wicked problem’s definition is subjective from the standpoint of the planner attempting to solve it, and the problem itself is usually not known from the start. Each planner involved in solving the problem views the problem through a separate frame-of-reference, which accounts for different views of what the problem actual is. These varying frames-of-reference can result in diametrically opposing views of the same problem. If the definition of the problem shifts and is not precisely known, how can a planner solve the whole problem when only a partial problem is being solved? The planner must attempt to gather all information pertaining to the problem and then, without bias, analyze all the information to generate the best possible understanding and solution of the whole problem.

Planners attempting to solve problems on the first attempt with solutions that are neither right nor wrong is extremely difficult. Compounding this dilemma even further is that the planner is not afforded the option of being wrong. Planners are faced with solving problems defined by the planner’s understanding of the problem. Then they must attempt to

choose the correct solution in order to solve the problem on the first attempt. Wicked problems are not forgiving of mistakes; any attempt on a wicked problem either solves the problem or forces the problem to change into a different problem requiring a different solution. For example, dissolving the Iraqi military in 2003 following the fall of Saddam's regime was seen as a solution to a perceived threat problem. Dissolving the Iraq military did eliminate a threat, but subsequently changed the nature of the threat from a conventional force to an insurgency. Planners had one chance to solve the problem. Their inability to solve the problem on the first attempt injected variables into the problem causing the problem to change. Once a problem changes, the frames-of-reference used to define the problem requires change as well; otherwise, the planner will attempt to solve the wrong problem with an inappropriate solution. Planners do not have the prerogative to iteratively solve wicked problems.

Before this discussion goes any further the concept of the wicked problem-complex needs expounding on, so that the reader is not confused between wicked problems and wicked problem-complexes. A wicked problem-complex is the gestalt, or whole, of everything associated with the wicked problem not just the wicked problem itself. This whole is composed of, but not limited to, the problem symptoms, factors, frames of reference, stakeholders, solutions, and the problem itself.

Consider the wicked problem as a source of energy, neither positive nor negative, that influences the entire contextual environment surrounding it. The source of energy is not always detectable directly with traditional means, but the perceivable interactions of the surrounding environment indicate that something is changing dynamics in relation to the norm. The Arab Spring is an example of a wicked problem-complex. From different

frames-of-reference different communities indirectly identified a wicked problem by viewing directly the changing dynamics in the Arab world. There has not been the “aha” moment when everyone said “that” is the problem. Rather, the “aha” moment occurred when the problem-complex was identified.

Wicked Problem Solving

Rittel asserts that identifying the solution of a wicked problem happens at the moment when the wicked problem is also identified. Rittel further expounds that first generation systems approach problem solving is inadequate to solve wicked problems and that a systems approach of the second generation is required to handle wicked problems.²⁶ First generation systems approaches are linear in character, meaning that they follow discrete steps from problem identification to problem solution. The steps are:

1. Understand the problem.
2. Gather information-creative leap.
3. Analyze information.
4. Generate solution(s).
5. Assess solution(s).
6. Implement solution.
7. Test solution.
8. Reassess and modify solution.²⁷

Traditional U.S. military planning processes, i.e. the military decision making process (MDMP), fall into this category. The success of first generation systems analysis is that the problem and ensuing objective(s) are known from the beginning. All planners are required to do is link ways and means to achieve the objective which, in theory solves the problem. When the problem is a wicked problem, and the problem is not initially known, how can first generation systems analysis work? In order to follow the steps in a linear fashion, the planner must understand the problem first. In the case of wicked problems, the planner, not understanding the problem, could go no further in the process. The planner is required to

iterate between steps two through five to generate an understanding of the problem. Conklin illustrates this iterative, or “opportunity driven,” process as he describes how planning groups bounce between problem understanding and problem solution during the planning process.²⁸ Systems approach of the second generation takes advantage of group dynamics in driving opportunity driven problem solving. Design and GMA fall into systems approach of the second generation category with planners following a non-linear path that fluctuates between problem understanding and problem solution.²⁹

Quick History of GMA

GMA is a methodology that provides a way to understand and solve complicated and wicked problem-complexes through “non-quantifiable modeling methods relying on judgmental process and internal consistency, rather than causality”.³⁰ The foundations of GMA was developed by Fritz Zwicky around a morphological approach/analysis (MA) theory as a way to determine all possible solutions of all problem types through the study of relationships between all bounding parameters of the problem, without the influence of bias or prejudice.³¹ Zwicky developed MA methods to solve complicated science and engineering problems. Zwicky’s most notable MA use was developing different forms of jet/rocket propulsion systems and identifying the existence of supernovas long before there was technology available to physically observe them.³² Zwicky uses six methods and principles to conduct MA: method of morphological box, method of systematic field coverage, method of negation and construction, method of the extreme, confrontation of perfection and imperfection, and the method of generalization.³³

Between the emergence of OR and the end of the Cold War a few problem solving theorists expounded on the use of MA in solving wicked problems, but MA found little

support until Tom Ritchie and his colleagues began experimenting with Zwicky's MA and computer modeling technology.³⁴ In the early to mid 1990's, Tom Ritchey expanded the application of Zwicky's MA to post-Cold War wicked problems; Zwicky's MA coupled with technology is GMA.³⁵ GMA is dependent on human judgment to build morphological models, and only uses technology to sift through all the possibilities, which attempts to limit satisficing solutions.

Expansion on the Six MA Methods and Principles

As stated above, Zwicky based his MA on six methods and principles that must be discussed in a little more detail before delving into the GMA process. The morphological box is an expansion of typology analysis that compares and categorizes values of problem parameters, or their relationships, to each other. In other words the morphological box creates a referencing structure, a matrix, where all the possible combinations of a problem's parameters is constructed. This morphological box ideally contains all possible solutions of the problem.³⁶ Systematic field coverage involves the discovery of all aspects of a problem by investigating the problem-complex and recording all factors and relationships determined as part of the problem-complex.³⁷ Systematic field coverage is intended to find all possible aspects of the problem complex which can then be inputted into the morphological box, and is similar in nature to cognitive mapping that Conklin discusses. Negation and construction involves removing the bias and prejudice from the problem-complex and solutions, and then developing new solutions to the problem-complex.³⁸ The method of the extremes is based on a simple principle of not ignoring an idea because it seems improbable or is on the fringe of reality. Because of this method, the factors on the edge of a problem-complex are not treated as outliers but are included in an analysis and synthesis of the problem-complex.³⁹

Confrontation of perfection and imperfection is closely linked to the method of the extremes, but includes factors that are part of the problem-complex which seem inaccurate.⁴⁰ Finally, method of generalization involves looking at the problem-complex from expanded frames-of-reference to focus down onto a specific solution.⁴¹ In doing this the planner expands his view of the problem-complex allowing for unique and varied problem definitions and solutions to present themselves. Each of these methods and principles are powerful tools when used individually to solve problems, but when these six tools are used in conjunction with each other, the options that are generated are tremendous.

General Survey of the GMA Process⁴²

GMA consists of a total of four general processes divided into two phases according to Ritchey. The phases are the traditional aspects of problem solving: analysis and synthesis. The analysis phase of GMA consists of the first two processes: define dimensions/variables and define variable factors. The synthesis phase of GMA consists of the remaining two processes: cross-consistency assessment (CCA) and examine solution/outcome space.⁴³ Ideally, these four processes could be treated as linear steps in first generation systems analysis, but when dealing with wicked problem-complexes, these four processes approximate the opportunity-driven approach instead of discrete steps. From this point on in this discussion the term dimensions or variables will be referred to as parameters⁴⁴, and the values or conditions will be referred to as factors.

The analysis phase of GMA deals with breaking the problem-complex down into the component parts that best describe the aspects of the problem that is of interest to the planner. The outputs of GMA's first and second processes are used in filling the morphological tool, called a morphological field. The morphological field graphically

captures the parameters and parameter values generated in the first and second processes. Most likely a planner will not distinguish between parameters and factors until he begins to fill in the morphological field(s). A useful way to begin is to use cognitive mapping techniques to generate parameters and factors of the problem-complex. Using Zwicky's methods and principles of systematic field coverage, negation and construction, the extreme, confrontation of perfection and imperfection, and generalization the planner can develop an extensive cognitive map of the problem-complex. By grouping similar elements of the cognitive map together the planner begins to stratify the problem-complex into parameters and factors and can fill in the morphological field. Stratifying the cognitive map into parameters and factors can be challenging, but considering parameters as generalized or primary boundaries of the problem-complex and factors as supporting concepts of each parameter. The morphological field graphically represents a framed problem-complex. The morphological field, before undergoing CCA, can generate an unmanageable number of possible configurations; usually between tens-of-thousands to millions of configurations, depending on the number of parameters and factors in each parameter.⁴⁵

The synthesis phase of GMA deals with structuring the wicked problem-complex into a functioning model from which planners are able to generate courses of action. GMA's third process involves defining the nature of relationships between each of the factors through a pair-wise comparison, either inclusive or exclusive.⁴⁶ Each of the factors will be entered along the horizontal and vertical axis of a CCA matrix to determine the type of relationship existing between each factor-pair. An inclusive relationship between factors recognizes that there are no constraints or restrictions to those factors existing together in a solution space. Ritchey classifies the exclusive relationships between factors as logical

contradictions, empirical constraints or normative constraints. Logical contradictions are the least challenging relationships to identify because they represent true-false possibilities. Basically, if two factors can exist together then they are inclusive and if they cannot exist together then they are exclusive.

Empirical constraints are relationships that are harder to determine. These relationships between factors are not true-false but seen as likely-unlikely based on statistical probability. A planner may determine that two factors are logically inclusive but if the probability of them existing together is unlikely, then the two factors are empirically exclusive. Finally, normative constraints are relationships that are based on what society considers the normal, and should be used with caution.⁴⁷ CCA will dramatically reduce the number of possible configurations that is initially generated by the morphological field, usually by 90%-99%⁴⁸, and allow the planner to look at a manageable set of possible configurations.

GMA's fourth process involves the assessment of the configurations. The planner can designate certain factor(s) as drivers or inputs and view the resulting possible or output factors. This input-output configuration is a solution space of the framed problem-complex. The planner, not the computer program, chooses which solution space best generates courses of action that meets the desired intent of solving the problem. This will be explained further in the case study.

Morphological fields can be considered frames-of-reference of a problem-complex. Each problem-complex can be viewed from multiple frames-of-reference, and the best way to understand a problem-complex is to relate the frames-of-reference through commonalities. Ritchey calls this method of GMA modeling multiplex modeling. He defines three general

frames-of reference used in multiplex modeling. These three frames-of-reference are the contextual environment, the transactional environment, and the policy/strategy space.⁴⁹

GMA AS A DESIGN MECHANISM

When selecting a design mechanism a commander must ensure that the mechanism includes all three design elements, facilitates all five design fundamentals, and meets all four design goals. If the mechanism does not accomplish all three tasks, then the commander will execute only a partial solution that may generate unintended consequences or not solve the problem. Recent history provides many examples of design mechanisms, EBO and SOD, which were wanting in any one these three areas. GMA, on the other hand, lends itself well as a mechanism for design, because it includes all three design elements, facilitates the five design fundamentals and meets the four design goals. The Colombia-FARC problem-complex is used to explore the applicability of GMA as a design mechanism. The Colombia-FARC model⁵⁰ will relate two frames-of-reference to meet design's goals. These two frames-of-reference are set into two morphological fields, the FARC Conceptual Environment and the Colombian Solution Space, to provide an unbiased frame of the problem-complex and generate operational approaches.

GMA and Design's Three Elements

Inherent in the three design elements are GMA's four processes. Design's framing the operational environment is harmonious with GMA's first and second processes, defining the problem-complex parameters and conditions. Likewise, design's framing the problem corresponds with GMA's first and second processes as well with its third process, CCA. Finally, design considers operational approaches, to include all four of GMA's processes. Figure 1⁵¹ provides a graphical depiction of these three relationships.

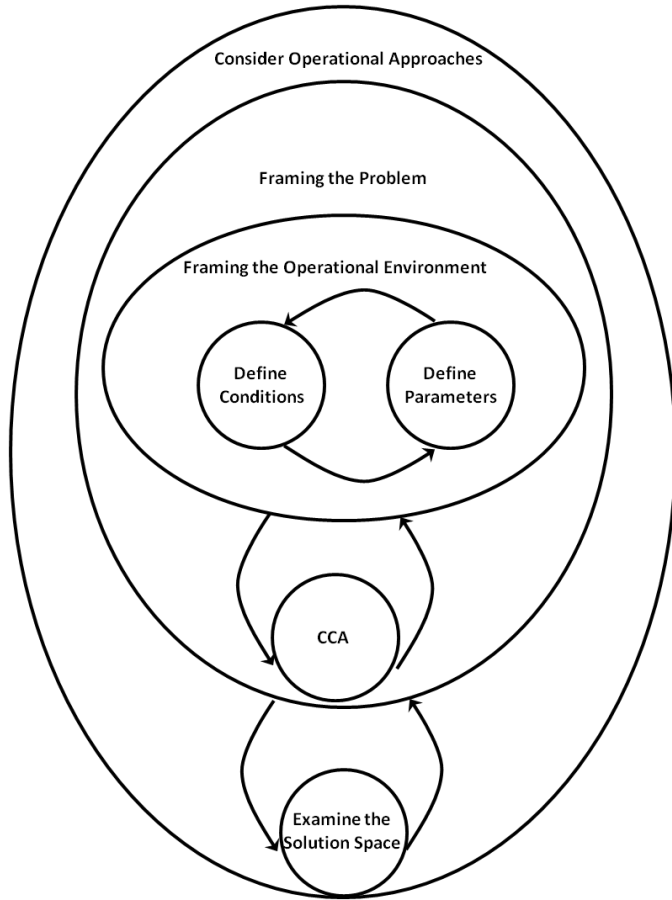


Figure 1: Relationship between Design's three elements and GMA's four processes.

Design is non-linear in concept and does not set firm boundaries between the elements, allowing free movement of cognitive thought between the three elements as planners oscillate between problem understanding and problem solution.⁵²

With that in mind, design treats framing the operational environment as a separate event from framing the problem. This abstract separation of frames is problematic if the planner

fails to recognize that when dealing with wicked problems the operational

environment also includes the problem frame. Planners framing the operational environment of a wicked problem-complex should remember that for any wicked problem there is no definitive definition. Every wicked problem is unique and can be considered a symptom of another wicked problem, and that problem solution is dependent on the frame(s)-of-reference defining the wicked problem. With this in mind, framing the operational environment is not a separate event from framing the problem but is only an expanded understanding of the problem frame. Using GMA, the planner frames the operational environment and problem by defining the parameters of the problem-complex, setting the initial frame(s)-of-reference. At the same time, the planner sub-defines the parameters with relevant factors that may affect

the solution space. This further definition narrows the planner's frame(s)-of-reference of the problem-complex leading to increased understanding of the problem and problem solution.

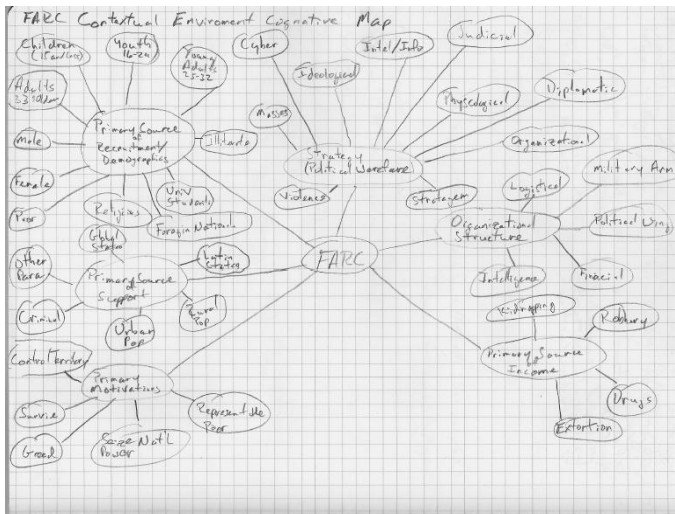


Figure 2: FARC Cognitive Map

GMA prevents the planner from inadvertently treating the operational environment frame as a separate entity from the problem frame.

In the Colombia-FARC case study, the FARC will be considered a part of the problem-complex and as such can be treated as a contextual

environment, not the direct problem. Setting the FARC as one frame-of-reference of the problem complex and using creative and critical thinking in the form of cognitive mapping a

FARC Organizational Structure	FARC Strategy (Political Warfare)	Primary Source of Recruitment/Demographics	Primary Source of Support	Primary Source of Income	FARC Objectives
Military Arm (Guerrillas)	Intelligence/Information	Youth/Children (Age 15 and Younger)	Rural Colombian Population	Illicit/Narcotic Drug Trade (65%)	Seize National Power and create a socialist institution
Political Wing (UP)	Ideological	Students (Age 16-24)	Urban Colombian Population	Robbery	Represent the Rural/Poor/Underprivileged Colombian
Financial (Income)	Psychological	Young Adults (25-32)	Local Latin American States	Extortion	Control Territory
Intelligence	Masses (People)	Adults (33 and older)	Global States	Kidnapping	Survive
Logistical (Transportation/Material/etc)	Organizational	Illiterate	Other Colombian Paramilitary Organizations		Greed/Economic Gain
	Judicial	University Students	Criminal Elements		
	Cyber	Religious			
	Diplomatic	Male			
	Stratagem	Female			
	Kinetic/Violence	Poor			
		Foreign Nationals			

Figure 3: FARC Morphological Field

morphological field was created to represent the FARC. See Figure 2 and Figure 3 for the FARC cognitive map and resulting morphological field. This FARC frame-of-reference consists of six parameters: FARC organization, FARC strategy (political warfare), primary source of recruitment and demographics, primary source of support, primary source of income, and FARC objectives⁵³. Each of these parameters consists of a range of factors that further defines the FARC. In this frame of reference there are 66,000 possible solution

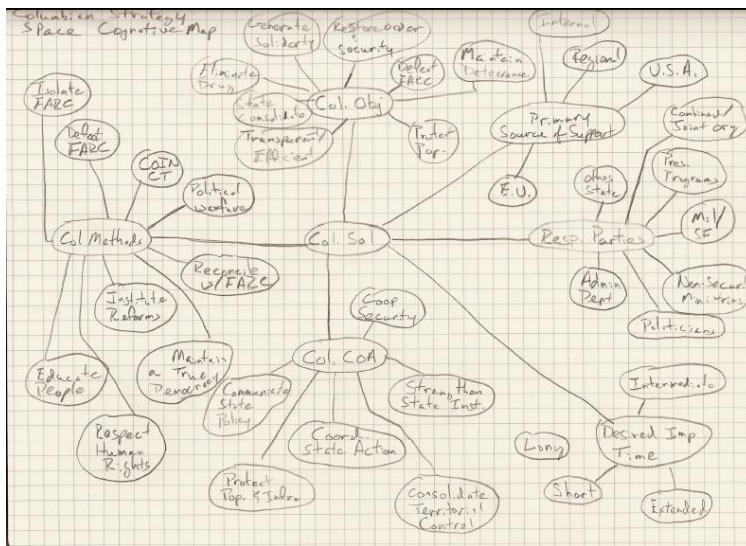


Figure 4: Colombian Cognitive Map

spaces based on the varied relationships between the factors.

Defining the FARC as a contextual environment provides a partial understanding of this problem-complex, but an additional frame-of-reference of

the Colombian strategy is required to fully understand the problem. Once again using cognitive mapping, a morphological field was developed that represented the Colombian strategy space.⁵⁴ See Figure 4 and Figure 5 for the Colombian strategy cognitive map and resulting morphological field. The Colombian strategy frame-of-reference, coincidentally, consists of six parameters: Colombian objectives, responsible parties, desired implementation time, Colombian courses of action, primary sources of support, and Colombian methods. In this frame-of-reference there are 55,296 possible solutions spaces based on the varied relationships between the factors.

Colombian Objectives	Responsible Parties	Desired Implementation Time	Colombian Courses of Action	Primary Sources of Support	Colombian Methods
Restore Order and Security	Military/Security Forces and National Police	Short (0-5 years)	Co-ordinate State Action	Internal	Isolate the FARC
Defeat the FARC	Non-Security Related Ministries	Intermediate (6-10 years)	Strengthening State Institutions	Regional	Decapitate the FARC
Generate Solidarity between the People and Government	Administrative Departments	Long (11-20 years)	Consolidating Control of National Territory	U.S.A.	Educate the People
Consolidation of State Control Throughout Colombia	Presidential Programmes	Extended (20+ years)	Protecting the rights of all Colombians and the Nations Infrastructure	European Union	Institute Policy/Social Reforms
Protection of the Population	Other State Institutions		Co-operating for the security of all		Conduct COIN/CT
Elimination of the Illegal Drugs Trade in Colombia	Colombian People		Communicating state policy and action		Reconcile with Former FARC Members
Maintenance of a Deterrent Capability	Combined/Joint Organizations				Respect Human Rights and Liberties
Transparent and Efficient Management of Resources	Politicians				Exercise Political Warfare
					Maintain a True Democracy

Figure 5: Colombian Strategy Scenario

There are two significant aspects of the parameters that warrant explanation. The first aspect is that there is no parameter that is specifically defined as a problem. Each of the parameters identifies a boundary that defines the FARC or the Colombian strategy. This is important in preserving the unbiased aspect of the problem-complex in GMA. The second aspect is that there are parameters that use the descriptive term “primary”. This is important for two reasons. First, there are normally a significant amount of conditions that define a parameter. If secondary factors are included in parameters, what are the important definitions of that specific parameter? Second, for every condition that is added there is a substantial increase in the number of solution spaces that require consideration. Other planners may have defined these two frames-of-reference with different parameters and factors, which highlights the difficulties and diversity in understanding the problem.

The process of building these two frames-of-reference is essentially similar in nature to the Marine Corps “Problem Framing” step in the Marine Corps Planning Process.⁵⁵ The problem framing process defines the operational environment, and maybe even the problem,

		Outcome Scenario					FARC Organiz				
		BO Controls Colombia	has limited Control	enable a Settlement	a Political Entity	Initial FARC Hostilities	and FARC has limited	Military Arm (Guerrillas)	Political (Monarchy)	Financial (Economic)	Intelligence
FARC Organizational Structure	Military Arm (Guerrillas)	-	-	-	x	-	-				
	Political Wing (Monarchy)	-	-	-	-	-	-				
	Financial (Economic)	-	x	x	-	-	-				
	Intelligence	-	-	x	k	-	-				
	Logistical (Transportation)	-	x	x	x	-	-				
FARC Strategy (Political Warfare)	Intelligence/Inf	-	-	-	-	-	-	-	x	-	x
	Ideological	-	-	-	-	-	-	-	x	-	x
	Physiological	-	-	-	-	-	-	-	k	-	x
	Masses (People)	-	-	-	-	-	-	-	-	-	-
	Organizational	-	-	x	-	-	-	-	-	-	-
	Judicial	-	x	x	-	-	-	-	-	-	x
	Cyber	-	k	k	-	-	-	k	-	-	x
	Diplomatic	-	k	-	-	-	-	k	-	-	x
	Strategem	-	-	-	-	-	-	-	k	-	k
	Kinetic/Violence	-	-	x	x	-	-	x	-	-	k

Figure 6: Completed FARC CCA (See Figure A.1, Appendix 1 for complete CCA)

which provides planners with an increased understanding of the problem-complex. Critical and creative thinking then leads to the development of a course of action, or solution.

Unfortunately, in a wicked problem the solution is not always apparent by just defining the parameters and factors of the environment and problem. What is missing in this process is the

understanding of the relationships between parameters and factors. Understanding these relationships will further frame the problem and will also reduce the possible solution spaces. In GMA, this is done in through the CCA to restrict the operational environment and problem frame through the relationships of the factors by cross-checking each factor for consistency with all other factors.

In the Colombia-FARC case study two CCAs were conducted to further frame the problem-complex. Figures 6 and 7 show, respectively, the completed CCA for the FARC and Colombian strategy frames-of-reference used in this case study. Inclusive relationships

between factor-pairs were denoted with a “-” in the CCA matrix. Factor-pairs whose relationships were determined exclusive from logical contradictions or empirical constraints were denoted with an “x” in the CCA matrix. The remaining factor-pair relationships that were determined as possible, but not likely, by normative constraints were denoted by a “k” in the CCA matrix. Through this process the possible solution spaces for the FARC and the Colombian strategy frames-of-reference were reduced by 96%.

At this point the operational environment and problem is framed. Relationships between parameters and conditions are established within each frame-of-reference, but the

relationships between the FARC and Colombian strategy frames-of-reference have not yet been established.

Combining both frames-of-reference into one frame will result in over three billion possible solution spaces.

Instead of directly combining the frames-of-reference into one, another parameter is defined which relates to both frames-of-reference. In this

case the parameter “Outcome Scenario” is defined with six

		Outcome Scenario						Colombian Objectives									
		FARC Controls Colombia	FARC Organization Resolved Completely	Colombia and FARC Reach a Settlement	FARC Transforms into a Political Entity Only	No Change in Colombian FARC Hostilities	Colombia and FARC Resolved	Restore Order and Security	Rebuild the FARC	Identify between the People and Government	Stabilization of State Control Throughout Colombia	Protection of the Population	Reduction of the Internal Arms Trade in Colombia	Maintenance of a Balance of Power	Efficient Management of Resources		
Colombian Objectives	Restore Order and Security	x	-	-	-	x	x										
	Defeat the FARC	x	-	x	x	x	x										
	Generate Solidarity between the People	k	-	-	-	k	x										
	Consolidation of State Control Throughout Colombia	k	-	-	-	k	k										
	Protection of the Population	k	-	-	-	-	-										
	Elimination of the Illicit	x	k	k	k	k	k										
	Maintenance of a Defensible Capability	x	-	-	-	-	x										
Responsible Parties	Transparent and Efficient Management	k	-	-	-	k	k										
	Military/Security Forces and National Non-Security Related	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	
	Administrative Departments	x	x	-	-	-	x	-	x	-	-	x	-	x	-		
	Presidential Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	Other State Institution	k	x	-	-	x	x	-	k	-	-	x	k	x	k		
	Colombian People	-	-	k	k	-	-	-	-	x	-	-	-	x	x		
	Combined/Joint Organizations	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	Politicians	-	k	-	-	-	-	-	x	-	-	-	x	-	-		

Figure 7: Complete Colombian Strategy CCA (See Figure A.2, Appendix 1 for complete CCA)

conditions defined and Figure 8 and Figure 9 are depicting the frames-of reference with the added “Outcome Scenario” parameter. Once again, a CCA is conducted for each frame-of-reference reducing the possible solution spaces between the frames-of-reference by over 99%.

FARC Organizational Structure	FARC Strategy (Political Warfare)	Primary Source of Recruitment/Demo-graphics	Primary Source of Support	Primary Source of Income	FARC Objectives	Outcome Scenarios
Military Arm (Guerrillas)	Intelligence/Information	Youth/Children (Age 15 and Younger)	Rural Colombian Population	Illicit/Narcotic Drug Trade (65%)	Seize National Power and create a socialist institution	FARC Controls Colombia
Political Wing (UP)	Ideological	Students (Age 16-24)	Urban Colombian Population	Robbery	Represent the Rural/Poor/Underprivileged Colombian	FARC Organization Destroyed Completely
Financial (Income)	Psychological	Young Adults (25-32)	Local Latin American States	Extortion	Control Territory	Colombia and FARC Negotiate a Settlement
Intelligence	Masses (People)	Adults (33 and older)	Global States	Kidnapping	Survive	FARC Transforms into a Political Entity Only
Logistical (Transportation/Material/Vet c)	Organizational	Illiterate	Other Colombian Paramilitary Organizations		Greed/Economic Gain	No Change to Colombia/FARC Hostilities
	Judicial	University Students	Criminal Elements			Colombia and FARC Destroyed
	Cyber	Religious				
	Diplomatic	Male				
	Stratagem	Female				
	Kinetic/Violence	Poor				
		Foreign Nationals				

Figure 8: Complete FARC Morphological Field

FM 5-0 asserts that the purpose of framing the operational environment and the problem is to develop an understanding of the problem-complex, allowing commanders to make decisions leading to solutions.⁵⁶ Problem solutions are generated in design’s “consider operational approaches” element based on the level of problem understanding gained from the two framing elements. Figure 1 shows how GMA’s entire process nest with consider operational approaches, and leads to problem solution generation.

Completed GMA generates an “interactive inference model”⁵⁷ capable of investigating possible solutions to the problem-complex. Driving factors are selected as inputs to construct possible solution spaces. Planners evaluate the resultant solution spaces

as functions against designated evaluation criteria. The process of evaluating the constructed solution spaces is driven by the human factors of judgment and experience.⁵⁸ GMA will not engineer “The Solution”.

Outcome Scenarios	Colombian Objectives	Responsible Parties	Desired Implementation Time	Colombian Courses of Action	Primary Sources of Support	Colombian Methods
FARC Controls Colombia	Restore Order and Security	Military/Security Forces and National Police	Short (0-5 years)	Co-ordinate State Action	Internal	Isolate the FARC
FARC Organization Destroyed Completely	Defeat the FARC	Non-Security Related Ministries	Intermediate (6-10 years)	Strengthening State Institutions	Regional	Decapitate the FARC
Colombia and FARC Negotiate a Settlement	Generate Solidarity between the People and Government	Administrative Departments	Long (11-20 years)	Consolidating Control of National Territory	U.S.A.	Educate the People
FARC Transforms into a Political Entity Only	Consolidation of State Control Throughout Colombia	Presidential Programmes	Extended (20+ years)	Protecting the rights of all Colombians and the Nations Infrastructure	European Union	Institute Policy/Social Reforms
No Change to Colombia/FARC Hostilities	Protection of the Population	Other State Institutions		Co-operating for the security of all		Conduct COIN/CT
Colombia and FARC Destroyed	Elimination of the Illegal Drugs Trade in Colombia	Colombian People		Communicating state policy and action		Reconcile with Former FARC Members
	Maintenance of a Deterrent Capability	Combined/Joint Organizations				Respect Human Rights and Liberties
	Transparent and Efficient Management of Resources	Politicians				Exercise Political Warfare
						Maintain a True Democracy

Figure 9: Complete Colombian Strategy Morphological Field

GMA’s process is reminiscent of the Marine Corps’ problem framing step in that the problem-complex is constrained using various environmental factors to generate an understanding of the problem. In problem framing the commander and staff are required to generate and decide on the best possible solution that is dependent on perceived relationships between environmental factors. Very few commanders, and even fewer staff members, are truly capable of viewing, in the entirety, the relationship dynamics between environmental factors and selecting the best possible solution. Generally, the commander and staff will perceive only a few possible solutions, some better than others, but rarely the optimum solution. What GMA does is take the environmental factors integrated with designated relationships and presents an unbiased model that the commander and staff can explore in generating optimal operational approaches.

Using “Outcome Scenario” factors as driving inputs into the Colombian-FARC model, solution spaces are generated that can facilitate operational approach generation. Designating additional factors as input drivers will further constrain the model and facilitate additional understanding of an operational approach. For example, designating the factor “Colombia and FARC Negotiate a Settlement” in both frames of references generates the solutions spaces depicted in Figures 10 and 11. In this scenario, defeating the FARC and elimination of the illegal drug trade are not acceptable objectives so effort should not be

Outcome Scenarios	Colombian Objectives	Responsible Parties	Desired Implementation Time	Colombian Courses of Action	Primary Sources of Support	Colombian Methods
FARC Controls Colombia	Restore Order and Security	Military/Security Forces and National Police	Short (0-5 years)	Co-ordinate State Action	Internal	Isolate the FARC
FARC Organization Destroyed Completely	Defeat the FARC	Non-Security Related Ministries	Intermediate (6-10 years)	Strengthening State Institutions	Regional	Decapitate the FARC
Colombia and FARC Negotiate a Settlement	Generate Solidarity between the People and Government	Administrative Departments	Long (11-20 years)	Consolidating Control of National Territory	U.S.A.	Educate the People
FARC Transforms into a Political Entity Only	Consolidation of State Control Throughout Colombia	Presidential Programmes	Extended (20+ years)	Protecting the rights of all Colombians and the Nations Infrastructure	European Union	Institute Policy/Social Reforms
No Change to Colombia/FARC Hostilities	Protection of the Population	Other State Institutions		Co-operating for the security of all		Conduct COIN/CT
Colombia and FARC Destroyed	Elimination of the Illegal Drugs Trade in Colombia	Colombian People		Communicating state policy and action		Reconcile with Former FARC Members
	Maintenance of a Deterrent Capability	Combined/Joint Organizations				Respect Human Rights and Liberties
	Transparent and Efficient Management of Resources	Politicians				Exercise Political Warfare
						Maintain a True Democracy

Figure 10: Outcome Scenario Constrained Colombian Strategy Model

applied exclusively to achieve those objectives, as shown in Figure 10.

The planner is able to select one of the Colombian objectives as an additional driver to further frame the problem–complex. Further constraining the problem-complex allows for simplification in the operational approach, see Figure 12. Selecting the restore order and security as an additional driver does not drastically change the solution space. It does remove two possible primary methods of achieving the objective: educate the people and respect

FARC Organizational Structure	FARC Strategy (Political Warfare)	Primary Source of Recruitment/Demographics	Primary Source of Support	Primary Source of Income	FARC Objectives	Outcome Scenarios
Military Arm (Guerrillas)	Intelligence/Information	Youth/Children (Age 15 and Younger)	Rural Colombian Population	Illicit/Narcotic Drug Trade (65%)	Seize National Power and create a socialist institution	FARC Controls Colombia
Political Wing (UP)	Ideological	Students (Age 16-24)	Urban Colombian Population	Robbery	Represent the Rural/Poor/Underprivileged Colombian	FARC Organization Destroyed Completely
Financial (Income)	Psychological	Young Adults (25-32)	Local Latin American States	Extortion	Control Territory	Colombia and FARC Negotiate a Settlement
Intelligence	Masses (People)	Adults (33 and older)	Global States	Kidnapping	Survive	FARC Transforms into a Political Entity Only
Logistical (Transportation/Material/etc)	Organizational	Illiterate	Other Colombian Paramilitary Organizations		Greed/Economic Gain	No Change to Colombia/FARC Hostilities
	Judicial	University Students	Criminal Elements			Colombia and FARC Destroyed
	Cyber	Religious				
	Diplomatic	Male				
	Stratagem	Female				
	Kinetic/Violence	Poor				
		Foreign Nationals				

Figure 11: Output Scenario Constrained FARC Model

Outcome Scenarios	Colombian Objectives	Responsible Parties	Desired Implementation Time	Colombian Courses of Action	Primary Sources of Support	Colombian Methods
FARC Controls Colombia	Restore Order and Security	Military/Security Forces and National Police	Short (0-5 years)	Co-ordinate State Action	Internal	Isolate the FARC
FARC Organization Destroyed Completely	Defeat the FARC	Non-Security Related Ministries	Intermediate (6-10 years)	Strengthening State Institutions	Regional	Decapitate the FARC
Colombia and FARC Negotiate a Settlement	Generate Solidarity between the People and Government	Administrative Departments	Long (11-20 years)	Consolidating Control of National Territory	U.S.A.	Educate the People
FARC Transforms into a Political Entity Only	Consolidation of State Control Throughout Colombia	Presidential Programmes	Extended (20+ years)	Protecting the rights of all Colombians and the Nations Infrastructure	European Union	Institute Policy/Social Reforms
No Change to Colombia/FARC Hostilities	Protection of the Population	Other State Institutions		Co-operating for the security of all		Conduct COIN/CT
Colombia and FARC Destroyed	Elimination of the Illegal Drugs Trade in Colombia	Colombian People		Communicating state policy and action		Reconcile with Former FARC Members
	Maintenance of a Deterrent Capability	Combined/Joint Organizations				Respect Human Rights and Liberties
	Transparent and Efficient Management of Resources	Politicians				Exercise Political Warfare
						Maintain a True Democracy

Figure 12: Colombian Objective Constrained Colombian Strategy Model

human rights and liberties. Although restoring order and security” sounds noble, it primarily excludes two very important methods that are used in counter-insurgency/counter-terrorism. Possibly a better objective is generate solidarity between the people and the government, see Figure 13. In addition to the Colombian strategy frame, the planner should also include the

FARC environmental frame in generating the operational approach. Selecting Colombia and FARC negotiate a settlement highlights the primary FARC factors that Colombia should target to achieve the desired objective and endstate, see Figure 11.

The planner can continue selecting additional factors as drivers and further constrain the solution spaces, until the problem is either sufficiently understood or tamed to the point where an operational approach is generated. The planner may also experiment with different factor combinations which may generate effective solution spaces that would not normally be considered because of general bias. The solution spaces are varied and complicated, and the development of an operational approach is not dependent on GMA producing an answer, but on the planner perceiving an approach from how the problem is understood.

Outcome Scenarios	Colombian Objectives	Responsible Parties	Desired Implementation Time	Colombian Courses of Action	Primary Sources of Support	Colombian Methods
FARC Controls Colombia	Restore Order and Security	Military/Security Forces and National Police	Short (0-5 years)	Co-ordinate State Action	Internal	Isolate the FARC
FARC Organization Destroyed Completely	Defeat the FARC	Non-Security Related Ministries	Intermediate (6-10 years)	Strengthening State Institutions	Regional	Decapitate the FARC
Colombia and FARC Negotiate a Settlement	Generate Solidarity between the People and Government	Administrative Departments	Long (11-20 years)	Consolidating Control of National Territory	U.S.A.	Educate the People
FARC Transforms into a Political Entity Only	Consolidation of State Control Throughout Colombia	Presidential Programmes	Extended (20+ years)	Protecting the rights of all Colombians and the Nations Infrastructure	European Union	Institute Policy/Social Reforms
No Change to Colombia/FARC Hostilities	Protection of the Population	Other State Institutions		Co-operating for the security of all		Conduct COIN/CT
Colombia and FARC Destroyed	Elimination of the Illegal Drugs Trade in Colombia	Colombian People		Communicating state policy and action		Reconcile with Former FARC Members
	Maintenance of a Deterrent Capability	Combined/Joint Organizations				Respect Human Rights and Liberties
	Transparent and Efficient Management of Resources	Politicians				Exercise Political Warfare
						Maintain a True Democracy

Figure 13: ‘Generate Solidarity’ Constrained Colombian Strategy Model

GMA and Design's Five Fundamentals

Operations intended to handle wicked problems are themselves complex and wicked, requiring planners to function with uncertainty and risk. The purpose of design fundamentals is to mitigate the risks inherent in the problem-complex and those assumed by a commander when attempting to cope with the wicked problem. These five design fundamentals are apply critical thinking, understanding the operational environment, solve the right problem, adapt to dynamic conditions, and achieve the designated goals.⁵⁹ GMA facilitates the planner's use of the five design fundamentals depending on the planners' abilities to properly apply the fundamentals.

Application of critical thinking in the design process is necessary to alleviate ambiguity found in the problem-complex. This is done through careful evaluation of all aspects of the problem-complex, especially those constitutive aspects that drive the problem. Without critical thinking during the framing processes, the planner can be distracted by insignificant elements of the problem-complex and lose sight of the designated goals. The planner applies critical thinking when using GMA to define the relevant parameters of the problem-complex, identifying conditions, and finally in the CCA. Recall from earlier the cognitive maps for both the FARC and Colombian frames-of-reference, each map utilized critical thinking to develop the map and decide on the primary factors that significantly defined the perceived problem and solution. Other factors exist, but the factors used are those with perceived significance to the planner. Once factors were chosen as the frames-of-reference, the planner used critical thinking to define the relationships between them in the CCA.

Planners attempt to understand the operational environment by framing varying aspects of the problem-complex that are perceived to affect the problem. All other aspects are either placed into another frame or are ignored. Framing the operational environment was previously discussed in the design element section, but understanding the operational environment involves the application of the cognitive thought that went into that framing process. GMA facilitates understanding of the operational environment by having planners further identify those factors that formulate the problem parameters. Without this cognition of problem parameters and factors the planner will not fully appreciate the operational environment. The CCA of factor-pairs further facilitates the understanding of the operational environment by stratifying the relationships between factor-pairs that are inclusive and exclusive. All of this drives the planner to understand the operational environment and prevent the unintended formulation of the wrong problem.

Recall from earlier in the discussion that identification of a wicked problem and the corresponding solution to the wicked problem essentially occurs at the same time. Also, recall that the tenth characteristic of a wicked problem is “the planner has no right to be wrong.” GMA facilitates the planner’s choice of the problem frame as the planner experiments with input driving factors and views corresponding output factors that relate to a specific problem and solution space. The ability to view multiple problem frames and their corresponding solution spaces, through GMA, allows the planner to identify those factors that are volatile and can have dramatic impacts on the problem-complex. With this knowledge planners can isolate those volatile factors and mitigate the effects that those factors have on the problem-complex. This allows planners to adapt the problem frame and

solution spaces to minimize dynamic changes, otherwise known as unintended consequences, in the problem-complex.

Ultimately, planners must formulate a solution to the wicked problem that achieves the stated goals. A solution unable to achieve the designated goals is a useless solution. Planners must understand that the designated goals are part of the problem-complex and as such should either be seen as a problem parameter or as a factor. Using GMA, planners relate the goals to the other factors to determine if these goals are feasible based on the inclusive or exclusive relations found in the environmental and problem frames. If the goals are found feasible then planners can set them as inputs and observe the related solution spaces and consider operational approaches that include all factors of the selected solution spaces.

GMA and Design's Four Goals

Design's four goals are understanding ill-structured problems, anticipating change, creating opportunities, and recognizing and managing transitions. The four goals are the results of successful application of the design fundamentals to the design elements, and are intended as universal tools to aid planners in developing detailed solutions to wicked problems.⁶⁰ As described in the previous sections, GMA was shown to embody the three design elements and facilitate the application of the five design fundamentals. As such, a successful GMA of a problem-complex must also meet the four design goals.

Understanding an ill-structured problem, that is the real dilemma facing planners charged with dealing with wicked problems. The misconception with wicked problems is that there is no structure to them, but in reality the wicked problem has a well developed structure or relationships. The structure is so complicated and dynamic that the capability to

perceive the structure is difficult. As a mechanism for design, GMA is a useful tool for defining problem structure and assisting the planner in gaining a better understanding of the wicked problem. In the Colombia-FARC example the planner may initially define the problem as the FARC, but is the FARC really the problem or just the symptom of the problem? Further analysis of the chosen factors shows discontent of the poor, rural, and young adults with policies and actions of the Colombian government. From a certain frame-of-reference, the factors that are driving a schism between the Colombian majority and the Colombian government may be the actual problem; the FARC may actually be a viable solution to the problem. Reconciling the FARC and the Colombian government may then combine multiple solutions to solve the real problem.

FARC Organizational Structure	FARC Strategy (Political Warfare)	Primary Source of Recruitment/Demographics	Primary Source of Support	Primary Source of Income	FARC Objectives	Outcome Scenarios
Military Arm (Guerrillas)	Intelligence/Information	Youth/Children (Age 15 and Younger)	Rural Colombian Population	Illicit/Narcotic Drug Trade (65%)	Seize National Power and create a socialist institution	FARC Controls Colombia
Political Wing (UP)	Ideological	Students (Age 16-24)	Urban Colombian Population	Robbery	Represent the Rural/Poor/Underprivileged Colombian	FARC Organization Destroyed Completely
Financial (Income)	Psychological	Young Adults (25-32)	Local Latin American States	Extortion	Control Territory	Colombia and FARC Negotiate a Settlement
Intelligence	Masses (People)	Adults (33 and older)	Global States	Kidnapping	Survive	FARC Transforms into a Political Entity Only
Logistical (Transportation/Material/etc)	Organizational	Illiterate	Other Colombian Paramilitary Organizations		Greed/Economic Gain	No Change to Colombia/FARC Hostilities
	Judicial	University Students	Criminal Elements			Colombia and FARC Destroyed
	Cyber	Religious				
	Diplomatic	Male				
	Stratagem	Female				
	Kinetic/Violence	Poor				
		Foreign Nationals				

Figure 14: ‘Global States’ Constrained FARC Model

Change is an inherent aspect of a wicked problem since they are considered by some as complex and adaptive systems that respond to any influence, intended or unintended. Anticipating changes to the wicked problem assists in anticipating requisite changes to the operational approach. GMA allows a planner to isolate a factor and set it as either an

additional or single input to see how the factor affects the solution space. Sometimes a single factor either removed from the solution space or directly targeted can cause significant change in the operational approach. For instance, targeting the support given by global states to the FARC significantly constrains the solution space, see Figure 14. With the understanding of how the problem-complex changes as either global state support is either increased or reduced, the planner can begin to generate an operational approach that will either create opportunities to exploit that factor or generate operational approaches that will manage the transition from one solution space to another as a factor causes the problem-complex to adapt.

CONCLUSION

Like it or not, wicked problems are real and affect every aspect of the U.S. military problem-complex. Design is a necessary approach for solving wicked problems that the U.S. military is asked to respond to in the problem-complex. Without a design mechanism, planners will struggle to implement design and gravitate to the familiar; traditional linear military planning processes suited for tame and understood problems. GMA can function as a suitable, feasible, and complete design mechanism if accepted by the military planning community. GMA embodies the design elements allowing the planner to apply the five design fundamentals to achieve in general the four design goals. The bottom line is that GMA leads the planner to a greater understanding of the problem which is required in order to generate the best possible problem solution(s).

APPENDIX 1

[illegible]

Figure A.1: Completed FARC CCA

		Outcome Scenario	Columbian Objectives										Responsible Parties				Desired Im	Columbian Courses				Primary Sources of Sup			
Columbian Objectives	Restore Order and Security	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Defeat the FARC	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Generate Solidarity	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Consolidate the Peace	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Consolidation of State Control	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Protection of the Environment	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Elimination of the Illicit Economy	X	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k
	Maintenance of a Democratic Regime	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Transparency and Efficient Management	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Responsible Parties	Military/Security Forces and National Non-Security Related Administrative Departments	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Presidential Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Other State Institution	k	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Columbian People	-	-	k	k	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Combined/Joint Orgs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Politicians	-	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Desired Implementation Time	Short (0-5 years)	-	X	-	k	-	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Intermediate (6-10 years)	-	-	-	-	k	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Long (11-20 years)	-	-	-	-	X	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k
	Extended (20+ years)	-	-	-	-	X	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k
Columbian Courses of Action	Co-ordinate State Action	X	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Strengthening State Institutions	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Consolidating Control	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Protecting the rights of all Colombians and Cooperating for the security of all	-	X	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Communicating state	-	X	X	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Primary Sources of Support	Internal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Regional	-	k	-	-	-	-	-	X	X	X	-	X	X	-	-	-	-	-	-	-	-	-	-	-
	U.S.A.	k	-	-	k	-	-	-	X	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-
	European Union	k	k	-	k	-	-	-	X	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Columbian Methods	Isolate the FARC	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Decapitate the FARC	X	X	-	-	X	X	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
	Educate the People	-	k	-	-	-	k	k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Institute Policy/Social	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Conduct COIN/CT	k	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Reconcile with Former	-	X	-	-	X	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
	Respect Human Rights and Liberties	-	-	-	-	-	X	X	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
	Exercise Political Will	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Maintain a True Democracy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure A.2: Complete Colombian Strategy CCA

NOTES

- ⁱ U.S. Department of the Army, *FM 5-0, The Operations Process* (Washington, D.C.: U.S. Government Printing Office, 2010), 3-1.
- ⁱⁱ Tom Ritchey, *Wicked Problems – Social Messes: Decision Support Modeling with Morphological Analysis* (Berlin: Springer, 2011), 95.
- ⁱⁱⁱ Ibid., 98.
- ^{iv} Ibid., 8.
- ^v Ibid., 97.
- ^{vi} Ibid., 98.
- ^{vii} Ibid., 31.
- ^{viii} Ibid., 98.
- ^{ix} Ibid.
- ^x Ibid., 7. The term problem complex is used in this work, but is not defined and is left to the reader to infer its definition. This concept of problem-complex in this discussion is the idea of the author and will be expounded upon later as wicked problem complexes. Complex in this context is a noun and refers to the whole or group of factors of a wicked problem; it should not be confused with the adjective form referring to the intricacy and uncertainty of the wicked problem.
- ^{xi} Ibid., 100.
- ^{xii} Horst Rittel and Melvin Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* no. 4 (1973): 155-160.
- ¹³ Orson Scott Card, *Ender's Game* (New York: Tor Books, 1985), 198.
- ¹⁴ Ritchey, *Wicked Problems*, 7.
- ¹⁵ Thornton Page, "The Nature of Operations Research and its Beginnings," in *New Methods of Thought and Procedure*, ed. Fritz Zwicky and A.G. Wilson (New York: Springer, 1967), 10-12.
- ¹⁶ U.S. Department of the Army. *FM 5-0*, 3-1.
- ¹⁷ Milan Vego, "Systems versus Classical Approach to Warfare," *Joint Forces Quarterly* no. 52 (2009): 40.
- ¹⁸ Ibid.
- ¹⁹ Carl von Clausewitz, *On War* (New York: Knopf, 1993), 154-162.
- ²⁰ James N. Mattis, "USJFCOM Commander's Guidance for Effects-Based Operations," *Parameters* vol XXXVIII (2008): 23.
- ²¹ Ritchey, *Wicked Problems*, 12.
- ²² Ibid, 14.
- ²³ U.S. Department of the Army. *FM 5-0*, 3-7.
- ²⁴ Ibid, 3-2, 3-5, 3-7.
- ²⁵ Rittel and Webber, "Dilemmas in a General Theory of Planning," 155-160.
- ²⁶ Horst Rittel, "On the Planning Crisis: Systems Analysis of the 'First and Second Generations'," *Bedriftsokonomien* no. 8 (1972): 391-393.
- ²⁷ Ibid., 391.
- ²⁸ Jeff Conklin, *Dialogue Mapping: Building Shared Understanding of Wicked Problems* (West Sussex: John Wiley and Sons, 2006), 8.
- ²⁹ Ibid.
- ³⁰ Ritchey, *Wicked Problems*, 7.
- ³¹ Fritz Zwicky, "The Morphological Approach to Discovery, Invention, Research, and Construction," in *New Methods of Thought and Procedure*, ed. Fritz Zwicky and A.G. Wilson (New York: Springer, 1967), 277.
- ³² Fritz Zwicky, *Discovery, Invention, Research* (Toronto, Ontario: Macmillan), 211-213 & 256 -258.
- ³³ Zwicky, "The Morphological Approach," 284-294.
- ³⁴ Ritchey, *Wicked Problems*, 11-12.
- ³⁵ Ibid., 3-5.
- ³⁶ Fritz Zwicky, *Discovery, Invention, Research* (Toronto, Ontario: Macmillan), 107.
- ³⁷ Ibid., 43-44.
- ³⁸ Zwicky, "The Morphological Approach," 291-292.
- ³⁹ Ibid., 292-293.
- ⁴⁰ Ibid., 293.

⁴¹ Ibid., 294.

⁴² This section of the discussion leans heavy on Tom Ritchey's work with GMA and such the majority of the references in this section will come from his book *Wicked Problems – Social Messes*.

⁴³ Ritchey, *Wicked Problems*, 67.

⁴⁴ Ibid., 12.

⁴⁵ Ibid., 14.

⁴⁶ Ibid., 13-14.

⁴⁷ Ibid., 14.

⁴⁸ Ibid., 13.

⁴⁹ Ibid., 32.

⁵⁰ The Colombian-FARC model was built in the computer program CARMA developed by the Swedish Morphological Society. All model figures were captured from CARMA.

⁵¹ Ritchey, *Wicked Problems*, 67. The relationship between GMA's Processes is described in Ritchey's book. The author linked Design's Elements to GMA's Processes.

⁵² U.S. Department of the Army. *FM 5-0*, 3-8.

⁵³ ADM Guillermo E. Barrera (Ret), interview with author, March 13, 2012.

⁵⁴ Republic of Colombia, *Democratic Security and Defense Policy* (Columbian Government Printing Office, 2003).

⁵⁵ U.S. Marine Corps, *MCWP 5-1, Marine Corps Planning Process* (U.S. Government Printing Office, 2010), 2-1.

⁵⁶ U.S. Department of the Army. *FM 5-0*, 3-8.

⁵⁷ Ritchey, *Wicked Problems*, 14.

⁵⁸ Ibid., 7.

⁵⁹ U.S. Department of the Army. *FM 5-0*, 3-5.

⁶⁰ Ibid., 3-2.

Bibliography

- Barrera, Guillermo, interview by John Miller. *ADM (RET)* (2012).
- Card, Orson Scott. *Ender's Game*. New York: Tor Books, 1985.
- Clausewitz, Carl von. *On War*. New York: Knopf, 1993.
- Conklin, Jeffery. *Dialogue Mapping: Building Shared Understanding of Wicked Problems*. West Sussex: John Wiley & Sons, 2006.
- Department of the Army. "Field Manual (FM) 5-0." *The Operations Process*. Washington, D.C.: U.S. Government Printing Office, March 2010.
- Mattis, James N. "USJFCOM Commander's Guidance for Effects-Based Operations." *Parameters*, 2008: 18-25.
- Republic of Columbia. *Democratic Security and Defense Policy*. Columbian Government Printing Office, 2003.
- Ritchey, Tom. *Wicked Problems - Social Messes: Decision Support Modelling with Morphological Analysis*. Berlin: Springer, 2011.
- Rittel, H. "On the Planning Crisis: Systems Analysis of the 'First and Second Generations'." *Bedriftsokonomien* 8 (1972): 390-396.
- Rittel, H., and M. Webber. "Dilemmas in General Theory of Planning." *Policy Sciences* 4 (1973): 155-169.
- U.S. Marine Corp. *MCWP 5-1: Marine Corps Planning Process*. U.S. Government Printing Office, 2010.
- Vego, Milan. "Systems versus Classical Approach to Warfare." *Joint Forces Quarterly*, no. 52 (1st Quarter 2009): 40-48.
- Zwicky, F., and A. Wilson. *New Methods of Thoughts and Procedures: Contributions to the Symposium on Methodologies*. New York: Springer, 1967.
- Zwicky, Fritz. *Discovery, Invention, Research - Through the Morphological Approach*. Toronto: The Macmillan Company, 1969.